S1.4 - Counting particles by mass - The Mole

1.4.1 The Mole and Avagadro's Constant

1.4.2 Relative Atomic Mass (Ar) and Relative Formula Mass (Mr)

1.4.3 Molar Mass, Mass and the Mole

1.4.4 Empirical and Intermolecular Formulae

1.4.5 Molar Concentration and Solution Calculations

1.4.6 Avagadro's Law and Gas Volumes

Molar Mass, Mass and the Mole

Specification Reference S1.4.3

Quick Notes

- Molar mass (M) is the mass of 1 mole of a substance.
  - Units: g mol^{-1}
- We can link mass, moles, and molar mass, using the formula: **n = m ÷ M**
  - n = amount in moles
  - m = mass in grams
  - M = molar mass (g mol^{-1})
- Rearranged versions: **m = n × M** and **M = m ÷ n**
- Molar mass is numerically equal (same number) to the relative atomic or formula mass (M_r) but includes units.

Full Notes

What Is Molar Mass (M)?

The molar mass of a substance is the mass of one mole of that substance.

It is expressed in grams per mole (g mol^{-1}).

Molar mass is numerically the same as the relative atomic mass (A_r) or relative formula mass (M_r), but with units added.

Examples:

Hydrogen (H): A_r = 1.01 meaning M = 1.01 g mol^{-1}

Water (H_2O): M_r = 18.02 meaning M = 18.02 g mol^{-1}

The Relationship: n = m ÷ M

Moles, mass and molar mass can all be linked by this equation:

$$\text{moles (n)} = \frac{\text{mass (g)}}{\text{molar mass (g mol}^{-1}\text{)}}$$

We can rearrange this to find any unknown:

- To find mass: m = n × M
- To find molar mass: M = m ÷ n

Ex **WORKED EXAMPLE**

Finding moles from mass

1. Given: 36.04 g of water (H_2O), $M(H_2O)$ = 18.02 g mol^{-1}
2. n = m ÷ M = 36.04 ÷ 18.02

Answer: 2.00 mol

Ex

WORKED EXAMPLE

Finding mass from moles

1. Given: 0.50 mol of sodium chloride (NaCl), M(NaCl) = 58.44 g mol^{-1}
2. m = n × M = 0.50 × 58.44

Answer: 29.22 g

Ex

WORKED EXAMPLE

Finding molar mass

1. Given: 0.25 mol of a compound has a mass of 11.5 g
2. M = m ÷ n = 11.5 ÷ 0.25

Answer: 46.0 g mol^{-1}

Combining with Avogadro's Constant

We can convert between number of particles and moles using Avogadro's constant:

This allows us to go from mass to moles to particles.

Summary

- Molar mass connects the mass of a substance to the amount in moles.
- Use the formula n = m ÷ M to solve for any variable.

- Make sure your units match: mass in grams, molar mass in g mol^{-1}, amount in mol.

Linked Question

Q **REACTIVITY 2.1 – LINKED COURSE QUESTION**

How can molar masses be used with chemical equations to determine the masses of the products of a reaction?

Balanced chemical equations show the stoichiometric ratios between reactants and products. By using the **molar masses** of substances, these ratios can be converted into measurable quantities. The general process is:

1. Use the given mass of a reactant to calculate its amount in moles.
2. Apply the mole ratio from the balanced equation to find the moles of the desired product.
3. Multiply the product's moles by its molar mass to obtain its mass.

This method links the theoretical relationships in an equation to real laboratory quantities, allowing the prediction of product yields or reactant requirements.

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